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DAILY SYNOPTIC WEATHER MAPS FROM THE 1780s: A RESEARCH PROJECT OF SYNOPTIC CLIMATOLOGY

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Summary. The preparation of a series of daily synoptic weather maps for a number of years in the 1780s is described. The practicability of producing such charts is demonstrated by a discussion of the various sources of meteorological data which are available for this period. Illustrative examples are given of the weather maps being produced. Reference is finally given to methods by which these charts may be applied to improve our understanding of the climatic record over the past 200 years.

Introduction. The synoptic climatological research discussed in this paper is being sponsored by the Meteorological Office for the Meteorological Research Committee. The project was established in the Department of Geography, University College of Swansea in 1967 with the primary object of preparing a series of daily synoptic weather maps for a number of years in the 1780s, covering the area of the British Isles, western Europe and the eastern North Atlantic. In 1971 the working base of the project was transferred to the Climatic Research Unit in the School of Environmental Sciences, University of East Anglia. In assembling all known data for this period and area, over 80 inquiries were directed to scientists working in the fields of historical and synoptic climatology, meteorological services, universities, archives, libraries, scientific academies, learned societies and museums in the British Isles, Europe and the U.S.A. The response to this inquiry has been most rewarding, with the collected data providing a workable synoptic coverage over the specified area on a daily basis for an initial period of four years from 1781. Several research visits have also been made to collect data from archives in England and on the Continent. Preliminary inquiries at the sources of information have indicated that similar data are available for many years onwards from 1786.

Historical background. The search for ordered and rational explanations of natural phenomena was a characteristic feature of scientific inquiry during the eighteenth century. In meteorology, the long-held Aristotelian concepts of atmospheric phenomena were being questioned; concerted efforts, based on scientific observations, began to be made to understand the clearly apparent

fluctuations in the rhythm of the seasons which critically controlled the success or failure of the agricultural economies of most European states. Also the ancient hypothesis which suggested that epidemics were influenced by weather conditions began to be systematically investigated for the first time.

Eighteenth century scientific societies and meteorological observations. There were several attempts to organize meteorological observations on a systematic and collective basis during the eighteenth century. In 1723 a scheme for the collection of standardized weather reports was organized by James Jurin (1684–1750) under the auspices of the Royal Society and, for a time, observations were received from several locations in England, Europe, North America and India. In 1776 the Société Royale de Médecine (S.R.M.) was founded in France under the patronage of Louis XVI with Louis Cotte (1740–1815) as its scientific adviser. The objectives and achievements of this society have been discussed elsewhere (Kington[1]). A similar society, the first one to be specifically devoted to meteorology, the Societas Meteorologica Palatina (S.M.P.) was founded at Mannheim under the patronage of the Elector Karl Theodor with J. J. Hemmer (1733–90) as its director. The contribution of this society to the development of meteorological observing during the latter part of the eighteenth century has been discussed elsewhere (Kington[2]).

The activities of other scientific societies in northern Europe in establishing meteorological and astronomical observatories in Denmark, Norway, Sweden, the Faeroes, Greenland and Iceland (see Figure 1) have also been described elsewhere (Kington[3]). Most of the stations of these various networks were equipped with standard sets of instruments including a barometer, thermometers, hygrometer, rain-gauge and wind vane. The high-quality craftsmanship of instrument-makers during the eighteenth century allowed the design and construction of meteorological instruments to become quite sophisticated. Besides instrumental readings, observers were instructed to record significant weather, state of sky, clouds and wind strength; standardized abbreviations and symbols were used in the registers. Observations were usually made thrice-daily at the standard times of 07 h, 14 h and 21 h, and for the S.R.M. and S.M.P. networks, were entered on specially prepared forms which were periodically sent to the headquarters at Paris and Mannheim for analysis and interpretation (see Figures 2 and 3). Astronomical and phenological observations were also made by many of the observers. In England comparable efforts were made on a more individual basis by a dedicated group of amateurs mostly drawn from the medical and clerical professions. Observational procedures and findings were often compared, with the Royal Society providing a formal centre for the discussion and exchange of ideas. The efforts of Jurin to establish a network of observing stations under the auspices of the Royal Society earlier in the century had probably not been forgotten and reasonably standardized observations were being made on a daily basis at several locations in England during the 1780s. The usefulness of ships' log-books in providing meteorological data about conditions over the sea and in coastal regions off western Europe during this period has been discussed elsewhere (Oliver and Kington[4]). There are large collections of log-books from Royal Navy ships from about 1670 onwards at the National Maritime Museum and at the Public Record Office (see Figure 4). Log-books of vessels of the old East India Company are available at the India Office Records, Foreign and Commonwealth Office, London.

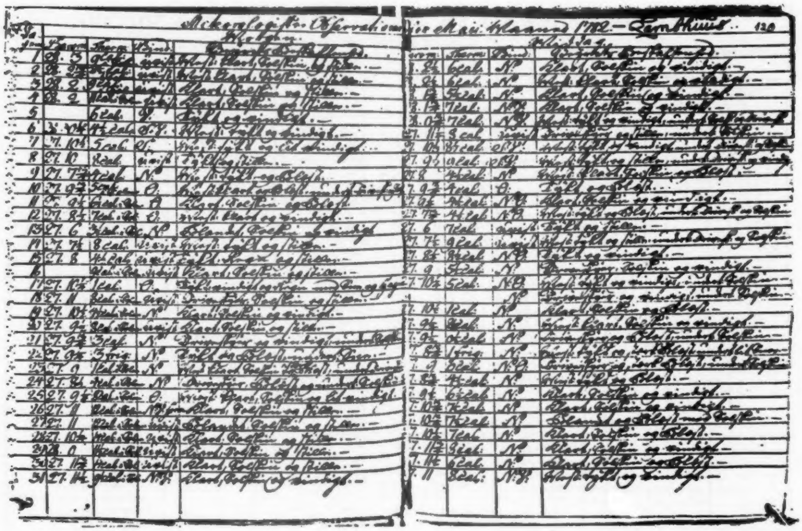

FIGURE 1—REGISTER OF OBSERVATIONS FOR MAY 1782 KEPT AT LAMBHÚS (ICELAND) BY RASMÚS LIEVOG

The two pages illustrated are of observations made in the morning (0600) and at midday (1200). The columns contain readings of barometer (Paris inches, lines, quarters or sixths); exterior thermometer (degrees Réaumur); wind direction; state of sky and significant weather. This last column also contains standard terms used by Danish observers to describe wind strength. (From Kington.[3])

Units. At stations in the British Isles, pressure was recorded in English inches and temperature in degrees Fahrenheit. On the Continent pressure was usually recorded in Paris inches and lines,* and temperature in degrees Réaumur, although there were a few exceptions, for example: Basel (pressure in millimetres and temperature in degrees Celsius); Stockholm (pressure in Swedish decimal inches and temperature in degrees Celsius up to December 1782); and Vienna where pressure was recorded in Viennese inches and temperature in degrees Celsius.

The approach of synoptic meteorology. Although a large number of weather observations were made and collected during the latter part of the eighteenth century, particularly from about 1780 onwards, the key factors for their meteorological analysis and interpretation had yet to be realized. It was only in the 1820s that H. W. Brandes (1777–1834), using data collected over Europe in the 1780s, constructed a series of daily weather maps which showed that the surface wind field was clearly related to the pressure pattern and that centres of low pressure tended to move from west to east. Unfortunately for the advancement of synoptic meteorology, the original charts that Brandes constructed do not appear to have been preserved, although a sample

*** 12 Paris inches = 144 Paris lines = 32·48 cm; 332·5 Paris lines = 1000·0 mb.**

FIGURE 2—REGISTER OF OBSERVATIONS FOR JULY 1789 KEPT AT ARRAS IN THE PROVINCE OF ARTOIS BY DR BUISSART FOR THE SOCIÉTÉ ROYALE DE MÉDECINE

Thrice-daily readings are given of exterior and interior thermometers (degrees Réaumur); hygrometer; barometer (Paris inches, lines and tenths); wind velocity; state of sky and significant weather.

A monthly climatological summary and observations relating to agriculture are also given.

The monthly incidence of illnesses and epidemics was recorded on the reverse of the form. (From Desaive, Goubert, Le Roy Ladurie, Meyer, Muller and Peter.[9]) Facsimile of the Société Royale de Médecine record appears by permission of the Secrétaire Perpétuel de l'Académie de Médecine, Paris.

map was later reconstructed by H. Hildebrandsson (1838–1925) for 6 March 1783 (see Figure 5). After the promising start by Brandes it was not until the present project was begun that a concentrated effort was again made to prepare a series of daily synoptic weather maps based on the wealth of material accumulated during the latter part of the eighteenth century, this time of course with the experience of present methods of synoptic analysis. The weather situation for 6 March 1783, as independently analysed in the present series, is given in Figure 6 and makes interesting comparison with that made by Brandes for the same day (see Figure 5).

Aims and objectives. The primary objective is the completion of daily charts for a number of years from 1781 so that a series for a workable period of time will be available for comparison with the daily synoptic maps that have already been classified and catalogued from 1861 by Lamb.[5] It will be possible to publish:

(a) Daily synoptic weather maps from 1 January 1781 for as many years as the project continues, covering the British Isles, western Europe and the eastern North Atlantic. An illustrative chart sequence is given in Appendix I.

-·8

OBSERVATIONES HAFNIENSES (1784)

Autore Bugge.

Horae observationis ordinariae 7 mat. 12 merid. 9 vesp.

Januarius.

	Dies.	Barom.	Therm. intern.	Therm. extern.	Hygr.	Declin.	Ventus.	Pluvia.	Evap.	Mare baltic.	Luna.	Coeli fac.	Meteora.
		ung. lin. dec.	gr. dec.	gr. dec.	gr. dec.	gr. min.	direct. vires.	poll. cub.	lin. dec	pollic.			
19	1	28, 2, 8	—0, 1	—6, 0	31, 4	18, 16				6		⊂	
		2, 9	0, 0	—3, 9	31, 0	16				6		⊙	
-5		3, 1	—0, 3	—5, 5	31, 3	16	ONO 2			2		⊙	
28	2	28, 4, 9	—0, 8	—6, 6	31, 7	18, 16	NO 2			—3		⊂	
		5, 9	—0, 4	—5, 2	31, 6	16	NO 2			1		⊂	
-7		6, 8	—0, 7	—6, 3	31, 5	14	ONO 3			8		⊙	
33	3	28, 7, 8	—0, 7	—4, 8	31, 3	18, 14	O 3			—4		==	
		7, 6	—0, 5	—4, 1	31, 1	13	OSO 3			16		==	
-5		9, 0	—0, 3	—3, 4	30, 9	15	SO 2			—14		=-	
41	4	28, 9, 8	—0, 4	—5, 0	31, 0	18, 15	SSO 2			—18		⊂	
		10, 1	—0, 3	—3, 9	30, 6	15	SSO 2			—35		⊂	
-5		9, 9	—0, 2	—3, 3	30, 4	15	SO 1			—29		=-	
41	5	28, 10, 0	—0, 3	—3, 5	30, 3	18, 15				—9		⊂	
		10, 0	—0, 2	—1, 7	30, 1	15	OSO 2			—22		⊂	
-2		10, 3	—0, 2	—1, 5	29, 4	15	O 1			—11		=-	
43	6	28, 10, 5	—0, 2	—2, 8	29, 3	18, 15	O 1			—7		⊙	
		10, 8	—0, 1	—0, 9	29, 2	15	O 1			—7		⊙	
-1		10, 7	—0, 2	—3, 0	29, 0	15	O 1			—9		==	⁙
39	7	28, 9, 9	—0, 3	—5, 0	29, 2	18, 15	SO 1			—4	☺ h. 2 m. 43	⊙	
		9, 5	—0, 3	—3, 1	29, 2	15	SO 2			—8	pom.	⊙	
-4		8, 7	—0, 3	—4, 2	29, 3	16	SO 2			—14		⊙	
32	8	28, 7, 5	—0, 3	—5, 8	29, 3	18, 16	SO 1			—10		⊙	
		7, 2	—0, 2	—2, 3	29, 3	17	SSO 2			—6		==	
-2		5, 9	—0, 2	—2, 7	29, 2	16	SSO 2			—16		=-	
27	9	28, 5, 6	—0, 1	—2, 7	29, 1	18, 16	SO 2			—15		==	
		5, 6	—0, 1	—2, 2	29, 0	16	SO 2			—14		==	
-3		6, 6	—0, 2	—3, 5	28, 8	16	SSO 2			—12		==	⁙
33	10	28, 7, 0	—0, 3	—6, 0	28, 8	18, 16	SW 2			—10		==	⁙
		7, 4	—0, 3	—5, 6	28, 8	16	SW 2			—4		==	⁙ circa merid.
-7		6, 6	—0, 5	—8, 0	29, 3	16	WSW 2			—5		+	
23	11	28, 4, 9	—0, 6	—6, 8	29, 3	18, 16	W 2			—12		==	⁙
		4, 1	—0, 5	—2, 0	28, 8	16	WSW 2			—4		==	
-3		2, 7	0, 0	1, 5	27, 8	16	W 2			—6		==	
17	12	28, 2, 3	0, 2	1, 5	25, 9	18, 16	WNW 2			—4		==	
		2, 3	0, 4	2, 1	25, 6	16	WNW 2			3		==	
3		2, 8	0, 5	1, 4	25, 2	15	WNW 1			—5		==	⁙ humida.
16	13	28, 2, 2	0, 5	1, 7	25, 4	18, 15	W 2			—4		==	
		1, 8	0, 7	1, 6	24, 9	14	W 2			—2		==	⁙ a merid. ad me-
-2		1, 1	0, 8	2, 5	25, 3	14	W 2			—2		==	diam noctem.
13	14	28, 0, 7	0, 9	2, 0	25, 0	18, 16	W 2			—4		==	⁙ ad vesp.
		0, 7	1, 1	2, 3	24, 6	19	W 2	28		—3		==	
3		27, 10, 9	1, 3	2, 5	24, 5	18	WSW 2			—3		==	
60	15	27, 9, 7	1, 3	2, 5	24, 5	18, 24	WSW 2			—4	☾ h. 5 m. 25	==	
		8, 5	1, 4	2, 8	24, 5	29	W 2			—8	vesp.	==	
3		4, 2	1, 3	0, 9	24, 5	27	NW 2			—13		==	‡ h. 10 & 11 vesp.

FIGURE 3—EXTRACT FROM THE EPHEMERIDES OF THE SOCIETAS METEOROLOGICA PALATINA, SHOWING OBSERVATIONS MADE BY PROFESSOR THOMAS BUGGE AT COPENHAGEN FROM 1 TO 15 JANUARY 1784

The columns contain thrice-daily readings (0700, 1200 and 2100) of barometer (Paris inches, lines and tenths); interior and exterior thermometers (degrees Réaumur); hygrometer; magnetic declination; wind velocity; height of Baltic; state of sky and significant weather. Rainfall and phases of the moon were also regularly recorded. (From Kington.[2])

(b) Monthly weather reviews giving the general synoptic situation for the entire area covered by the plotted data; wind, weather and temperature over selected area(s) of the chart (for example, central and southern England) and noteworthy events of meteorological and general significance that had occurred anywhere on the charts. A sample review for November 1784 is given in Appendix II.

(c) A classification of the daily weather types over the British Isles comparable to that contained in Lamb's register from 1861. Results obtained from the series of charts already completed are given in Table I.

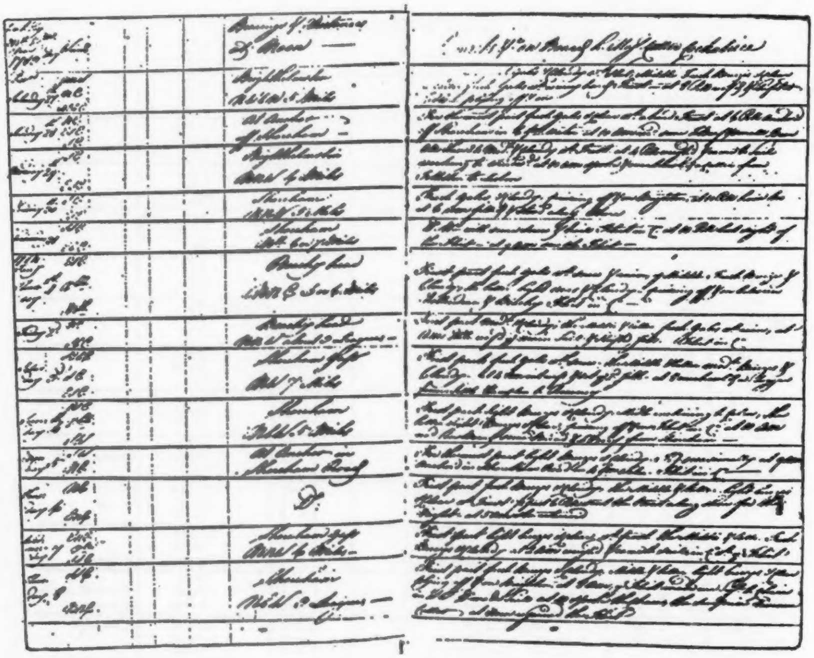

FIGURE 4—EXTRACT FROM LOG-BOOK OF H. M. CUTTER 'COCKATRICE' FROM SATURDAY 27 DECEMBER 1783 TO THURSDAY 8 JANUARY 1784, WHILST CRUISING OFF THE COAST OF SUSSEX

The entry for Thursday 1 January 1784 gives a typical example of the daily weather information that is obtainable from this source:
First part: ESE fresh gales with snow and rain;
Middle part: Variable fresh breezes and cloudy;
Latter part: N light airs and cloudy.
(From Oliver and Kington.[4]) Facsimile of Crown copyright record in the Public Record Office (reference ADM 51).

TABLE I—BRITISH ISLES DAILY WEATHER-TYPE FREQUENCIES 1781–84

		W	NW	N	E	S	A	C	U
1781	January	8	0	2	7	0	8	5	1
	February	11	8	2	0	1	3	3	0
	March	6	1	2	3	1	18	0	0
	April	8	1	1	2	3	9	5	1
	May	0	0	1	13	2	10	5	0
	June	2	1	0	5	2	3	16	1
	July	12	1	0	0	3	11	4	0
	August	2	1	1	1	0	5	19	2
	September	7	5	4	1	2	6	5	0
	October	5	5	4	0	1	15	1	0
	November	7	7	1	0	3	4	7	1
	December	7	0	0	5	10	1	7	1
	Year	75	30	18	37	28	93	77	7
1782	January	18	3	1	1	1	4	3	0
	February	6	0	2	8	1	8	3	0
	March	10	1	7	3	1	2	5	2
	April	0	1	3	14	1	1	9	1
	May	3	0	3	7	1	1	16	0
	June	6	3	0	1	3	9	7	1
	July	4	5	1	2	2	5	9	3
	August	8	5	3	0	1	0	14	0
	September	3	0	2	5	5	6	9	0
	October	6	6	3	3	1	8	3	1
	November	3	0	6	1	3	8	7	2
	December	8	5	1	1	3	12	0	1
	Year	75	29	32	46	23	64	85	11
1783	January	10	2	3	1	1	3	11	0
	February	9	1	2	1	0	5	10	0
	March	4	2	3	3	1	9	7	2
	April	5	0	2	5	3	14	0	1
	May	7	1	6	5	0	9	3	0
	June	5	0	1	1	2	12	8	1
	July	8	1	0	2	7	5	7	1
	August	4	0	1	1	2	7	13	3
	September	9	3	0	1	1	8	6	2
	October	6	6	3	3	1	8	3	1
	November	2	0	4	2	5	9	8	0
	December	1	0	0	4	5	16	4	1
	Year	70	16	25	29	28	105	80	12
1784	January	3	1	7	4	2	8	5	1
	February	3	2	8	6	3	5	2	0
	March	1	1	4	9	3	8	5	0
	April	4	5	5	1	0	7	8	0
	May	11	2	2	0	1	13	2	0
	June	6	4	3	3	1	2	9	2
	July	8	6	1	1	1	11	3	0
	August	6	3	4	3	1	11	3	0
	September	6	0	1	1	5	10	5	2
	October	1	2	2	5	3	16	2	0
	November	8	2	3	3	0	6	6	2
	December	0	2	7	8	0	9	5	0
	Year	57	30	47	44	20	106	55	7

Key to types:

W	Westerly	S	Southerly
NW	North-westerly	A	Anticyclonic
N	Northerly	C	Cyclonic
E	Easterly	U	Unclassifiable

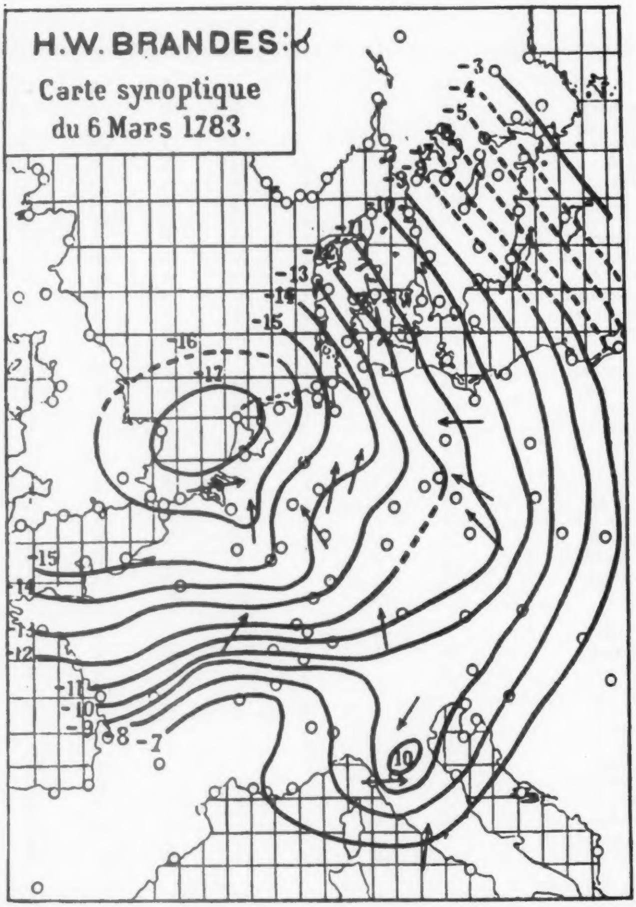

FIGURE 5—SYNOPTIC WEATHER MAP FOR 6 MARCH 1783 BY H. W. BRANDES

This chart was reconstructed from data analysed by H. W. Brandes and shows arrows of surface wind direction and isopleths of equal departure of pressure from normal. (From Ludlam.[10])

Future climatological research which should be possible with the aid of these synoptic weather maps could include:

(a) Classification and analysis of circulation patterns over the eastern North Atlantic–European sector, as an extension to the investigation already mentioned in (c) above.

(b) Determination of the most probable upper-air patterns and depression trajectories over the eastern North Atlantic–European sector.

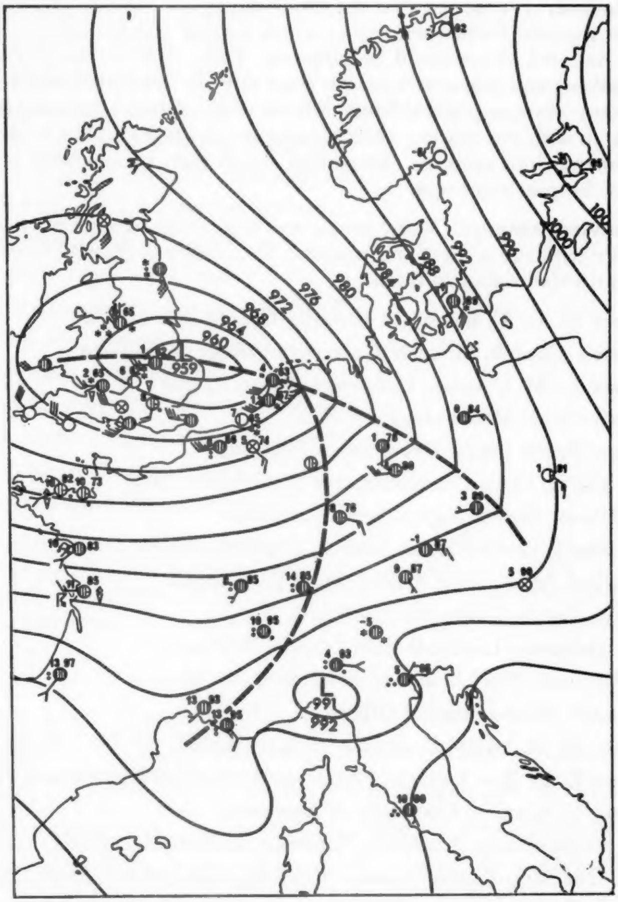

FIGURE 6—SYNOPTIC WEATHER MAP FOR 1400, 6 MARCH 1783 BY J. A. KINGTON

This chart forms part of the present series as discussed in this paper. Pressures are expressed in millibars.

(c) Analysis of a zonal index measured over the eastern North Atlantic–European sector.

(d) Analysis of weather singularities during the years studied.

(e) Application of the methods used by Murray and Lewis[6] and Murray and Benwell[7] to analyse weather types using *PSCM* indices.

(f) Comparison of temperature values associated with the same winds and weather types over selected periods with reference to methods discussed by Perry and Barry.[8]

Conclusion. It is hoped that the results being achieved in this project will provide a synoptic framework within which further climatological research of the type outlined above could be initiated. Data exist for the production of daily weather maps onwards from the years already completed and in the long run as many years as possible from 1781 to 1860 could be similarly treated so as to link up with the existing series of synoptic charts from 1861 to the present day. Research into synoptic climatology could then be extended on a daily basis over the past 200 years.

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British Museum, London
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Liverpool Record Office
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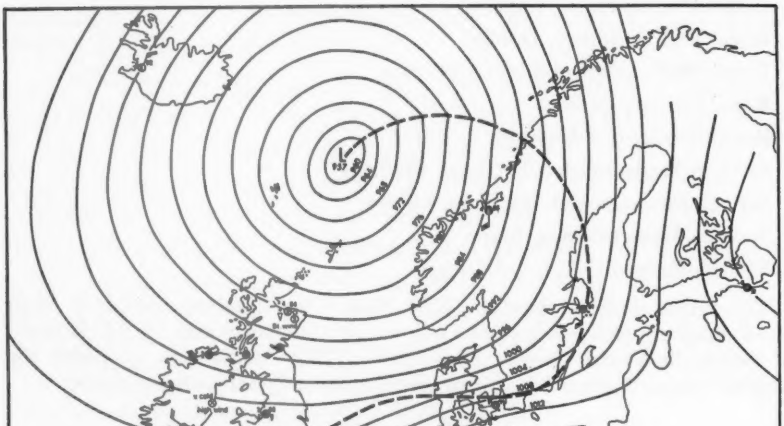
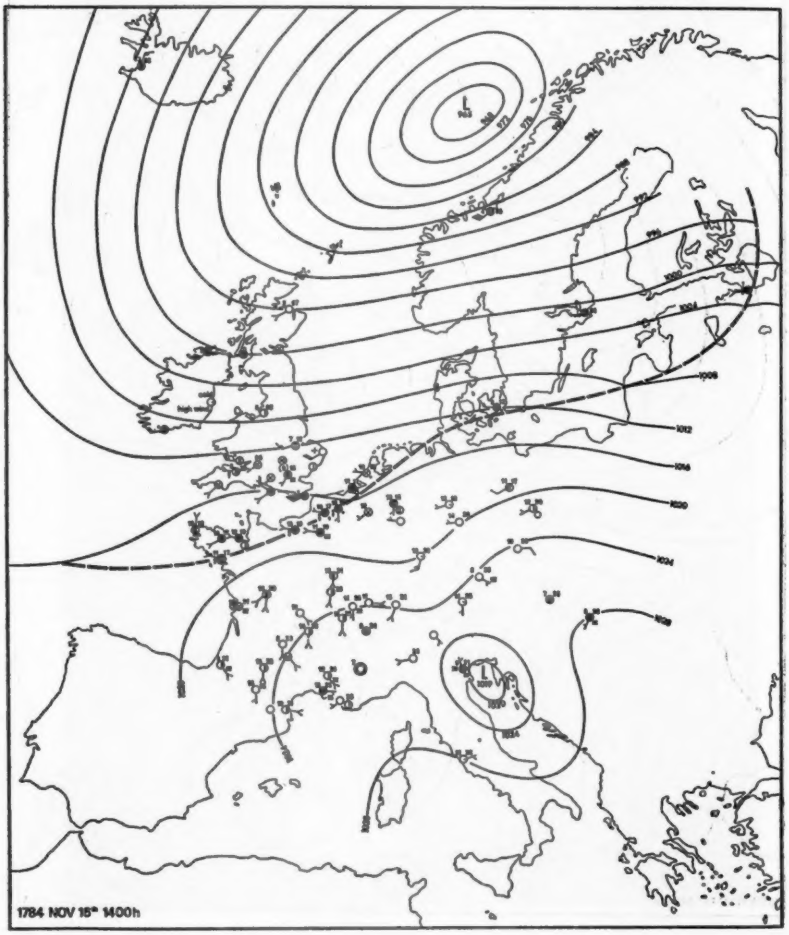
APPENDIX I—ILLUSTRATIVE CHART SEQUENCE FOR 15–21 NOVEMBER 1784

Pressures are expressed in millibars.

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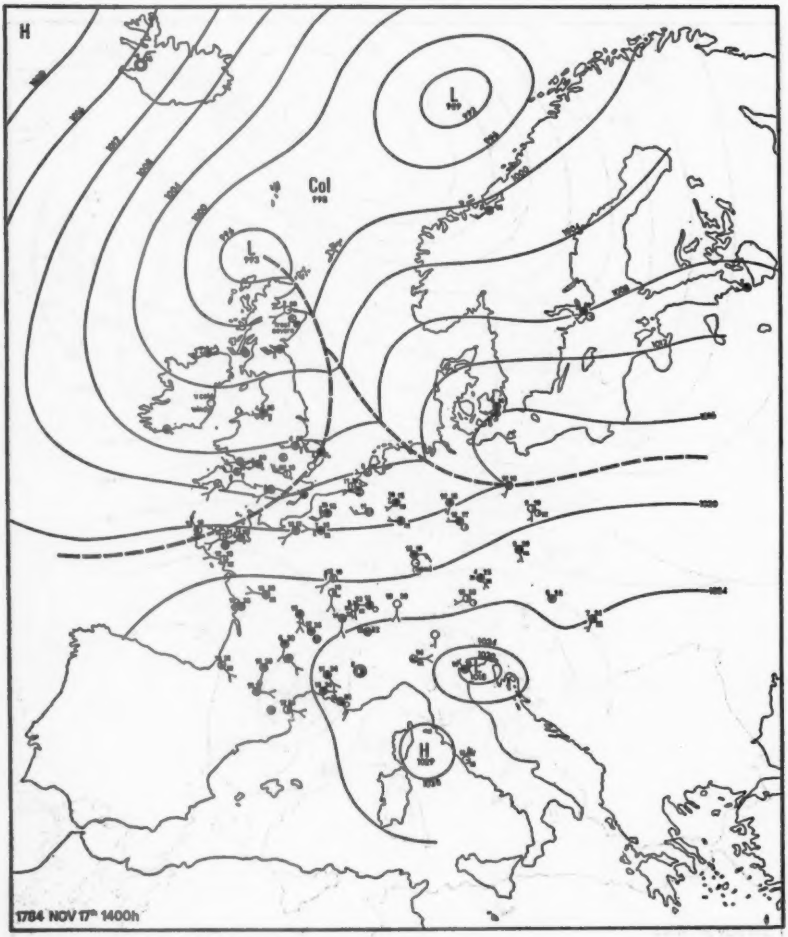
1784 NOV 16th 1400h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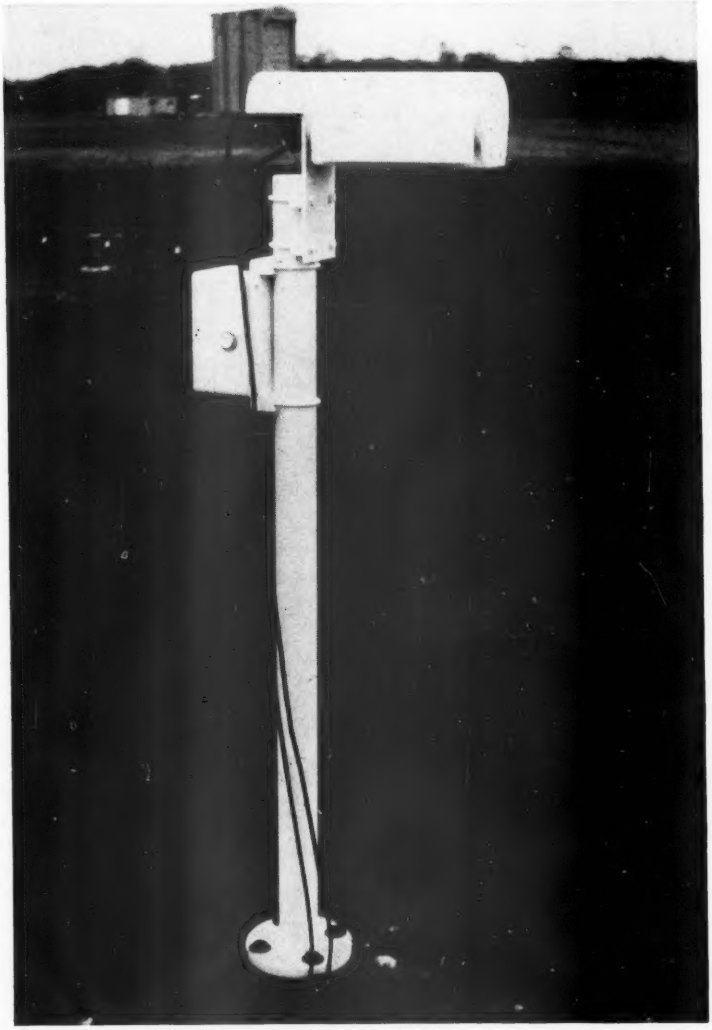


PLATE I—AUTOMATIC WEATHER STATION VERSION OF DEW-CELL SHOWING SIDE FLAPS ADDED TO ORIGINAL SHIELD

(See page 53.)

PLATE II—AWARD WINNERS WITH MAJOR AND MRS K. G. GROVES

Left to right: (seated) Mrs K. G. Groves, Major K. G. Groves, Air Marshal Sir Ruthven Wade, Air Commodore D. F. M. Browne; (standing) Flying Officer Trudi Cant, Dr C. J. Readings, Flight Lieutenant F. Robertson, Flight Lieutenant D. R. Gasson, Sergeant M. Dubey (see page 58.)

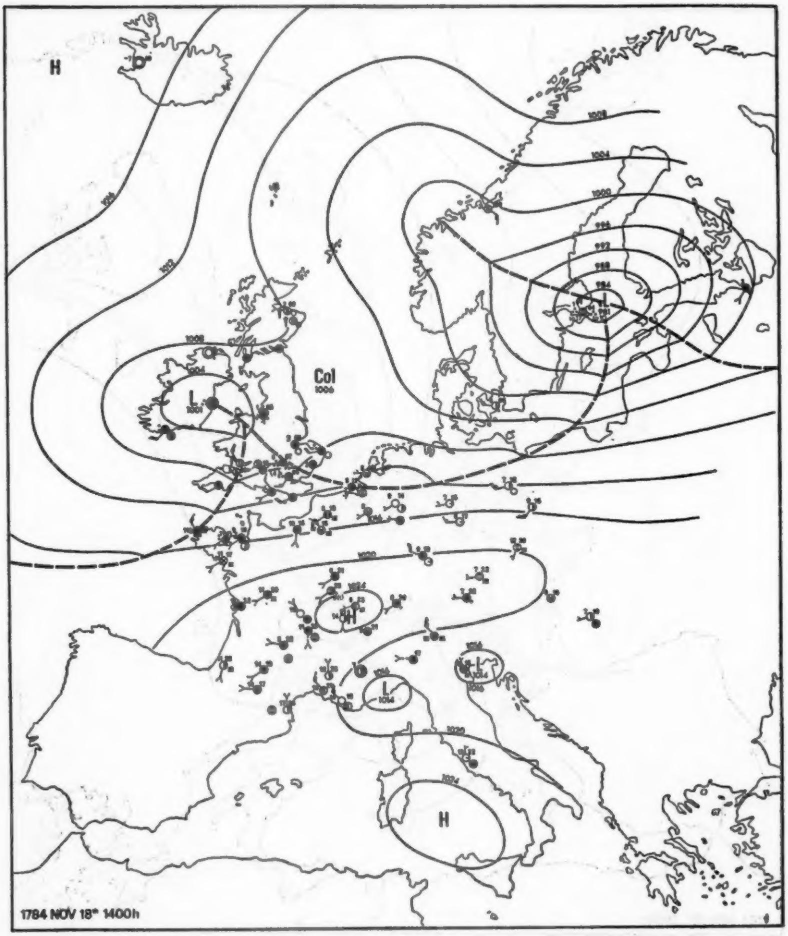
PLATE III—MAJOR K. G. GROVES WITH DR C. J. READINGS, WINNER OF THE PRIZE FOR METEOROLOGY
(See page 58.)

PLATE IV—MAJOR AND MRS K. G. GROVES AT THE PRESENTATION CEREMONY HELD ON 7 NOVEMBER 1974 ON THE OCCASION OF THEIR DIAMOND WEDDING ANNIVERSARY

(See page 58.)

PLATE V—MAJOR K. G. GROVES WITH FLIGHT LIEUTENANT F. ROBERTSON, WINNER OF THE AWARD FOR METEOROLOGICAL OBSERVERS

(See page 58.)



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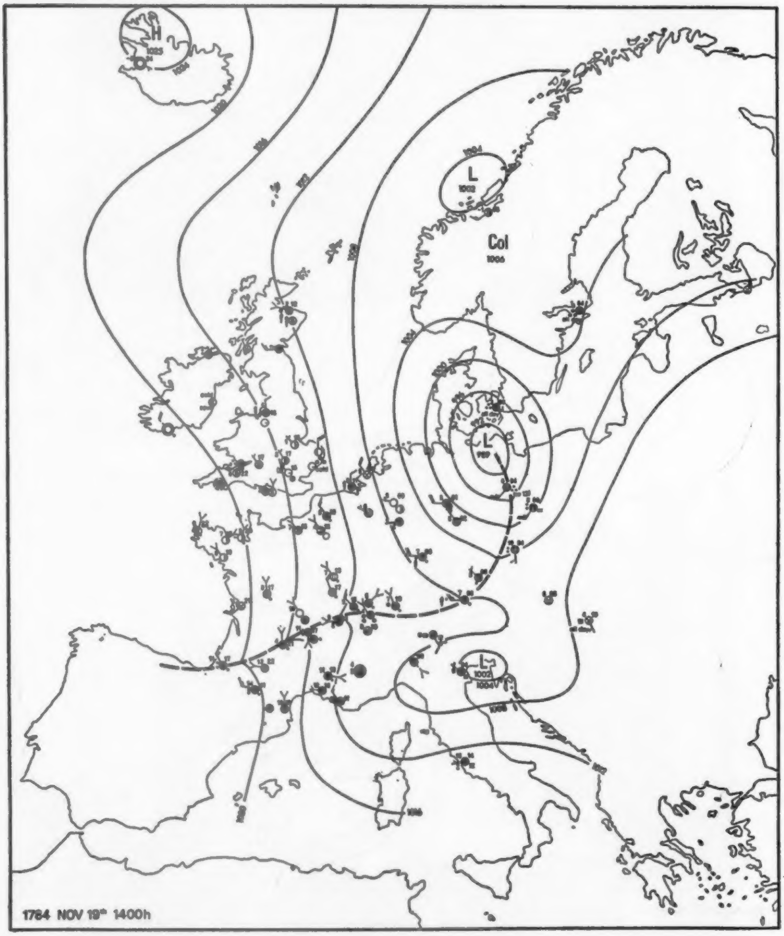

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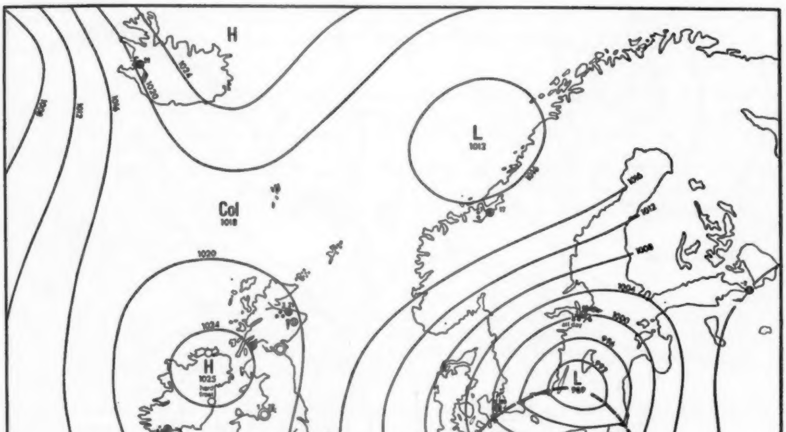
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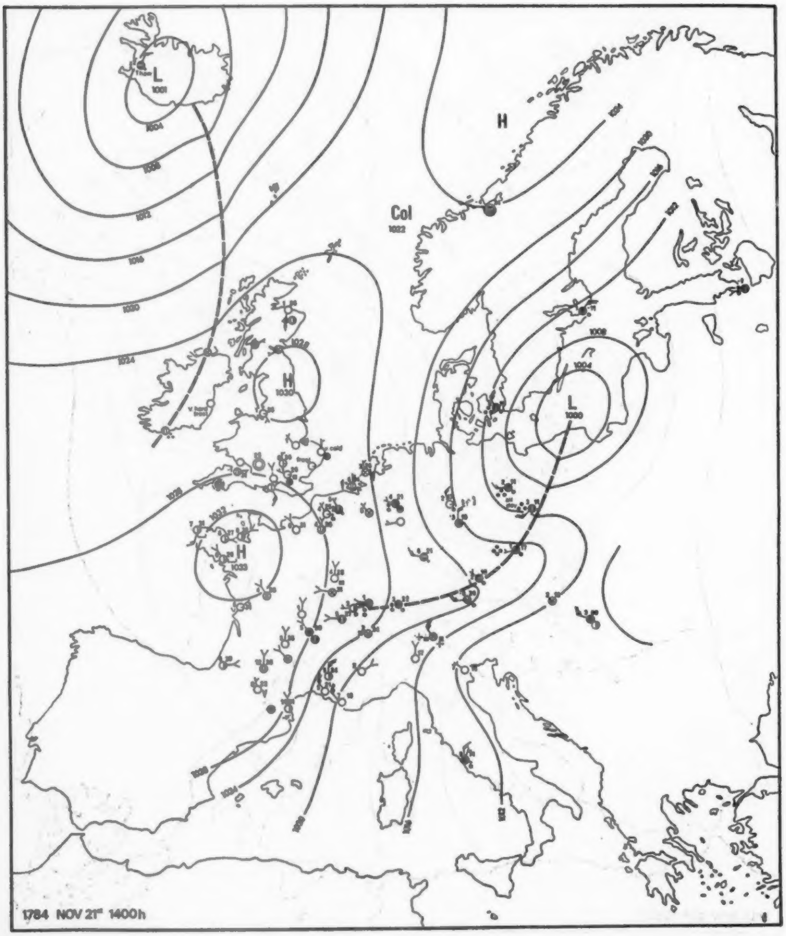

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APPENDIX II—EXAMPLE OF A MONTHLY WEATHER REVIEW NOVEMBER 1784—MOSTLY UNSETTLED AND WET—VERY COLD AT TIMES

In the following descriptions the significance of (a), (b), (c), (d) and (e) is as follows:

(a) General synoptic situation.
(b) Wind
(c) Weather } over central and southern England.
(d) Temperature
(e) Significant events occurring either within or outside defined areas.

1st–3rd
(a) A shallow depression moved east-north-east from the Midlands across the southern North Sea into the southern Baltic as the main centre of low pressure over Iceland moved east into the Norwegian Sea. An anticyclone developed over southern Germany on 2nd to 3rd.
(b) Light and variable.
(c) A moist airflow covered much of the Midlands and southern England on 1st giving occasional rain or drizzle. Brighter weather with occasional showers on 2nd and 3rd. Local morning fog patches occurred throughout the period, being particularly persistent in the London area on 1st and 2nd.
(d) Rather cold to normal.
(e) 2nd, *Milan*: Date of first snowfall (1784/85).

4th–7th
(a) An anticyclone over north-west Iceland and another which moved north-north-west from Poland into Scandinavia combined to form a single high-pressure system centred over the Orkneys on 7th. A depression moved east from the south-western Approaches across the Bay of Biscay and central France into north-east Italy.
(b) Light to moderate, SE backing to NE.
(c) Occasional rain or drizzle, especially on 5th, and local fog patches. Brighter weather with occasional wintry showers on 7th.
(d) Rather cold.
(e) 4th, *Selborne*: 'Great meteor' reported.

8th
(a) An anticyclone over Scotland on 7th moved quickly south-west to allow a disturbed W'ly flow to become established over the Norwegian Sea.
(b) Light and variable.
(c) Local morning fog patches, otherwise mainly dry with sunny periods.
(d) Very cold in inland districts.
(e) *Berlin*: Date of first snowfall (1784/85).

9th–18th
(a) A spell of cyclonic conditions: depressions over south-west Iceland, north-east England and Scandinavia deepened and appear to have become grouped together to form a large and complex area of low pressure with the main centre at first over northern Britain on 10th and then over Scandinavia on 12th. A further intense depression moved into the sea area between north-west Scotland and southern Iceland on 14th, and was centred about 200 miles east-north-east of the Faeroes on 15th with a strong W'ly flow over the British Isles. During 16th to 17th the depression filled and moved slowly north-east over the Norwegian Sea. On 17th to 18th two succeeding depressions moved east on increasingly southerly tracks from the eastern North Atlantic; the first skirted northern coasts whilst the second passed over Ireland and northern England.
(b) Moderate to fresh, occasionally strong, mostly SW, becoming cyclonic on 18th.
(c) Very changeable: occasional rain/drizzle or showers, continuous and moderate to heavy at times, some brief bright intervals.
(d) Variable: ranging from cold to normal; becoming mild in south on 11th, 14th and 15th.
(e) 15th, *Europe*: Aurora Borealis observed over a wide area of Europe on the evening and night of the 15th, with reports ranging from Iceland to northern Italy.

19th–21st
(a) High pressure over Iceland moved steadily east across the Norwegian Sea. An associated anticyclone over Northern Ireland on 20th moved east into northern England on 21st. A further anticyclone was centred over north-west France on 21st. A depression over northern Germany on 19th moved slowly north-east into the Baltic and filled. Cold air spread south over the British Isles and western Europe; particularly low temperatures were recorded over England at midday on 20th and 21st, e.g. −3°C at Mongewell, Oxon on 20th and −2°C in London on 21st.

(b) Light to moderate NW–NNW, becoming light and variable from the west on 20th–21st.
(c) Occasional wintry showers decreasing to become generally dry and sunny on 21st, apart from local fog or haze in London area.
(d) Very cold.

22nd
(a) With a depression over the Orkneys a weak front was located over England from the Wash to the south-western districts. A sharp ridge extended north-north-east into southern Norway from an anticyclone over south-western France; high pressure was also located over the Icelandic region. A strong N'ly flow occurred over southern Sweden and eastern Germany and gave widespread and continuous snow.
(b) Light and variable.
(c) Occasional rain or drizzle and fog patches early and late.
(d) Very cold.

23rd
(a) Depressions were located off south-west Iceland and over the Skaggerak. A ridge of high pressure extended northwards over the British Isles from an anticyclone over southern France.
(b) Light, NNW in east backing to WSW in west.
(c) Occasional drizzle and fog patches, some local bright intervals.
(d) Generally cold, but rising to normal in clearer conditions.

24th–27th
(a) With low pressure over the Icelandic region, a broad WSW'ly flow covered the eastern North Atlantic and most of the British Isles.
(b) Moderate, WSW backing to S on 27th.
(c) Occasional rain/drizzle becoming mainly dry from 25th. Local fog patches throughout.
(d) Normal.

28th–30th. A period of very changeable conditions.

28th
(a) An intense depression over the Norwegian Sea with a pronounced cold front moving eastwards across all districts of the British Isles.
(b) Moderate/fresh S veering to NW.
(c) A wide belt of continuous moderate to heavy rain over western districts moved east to affect central and eastern districts later in day.
(d) Normal becoming very cold.

29th
(a) Anticyclones located over Ireland and central Europe. The previous depression had filled and moved east-south-east into the Baltic with a wave developing on the trailing cold front over northern France.
(b) Moderate to fresh, NNE/NE.
(c) Continuous rain/drizzle over south-eastern districts becoming dry towards the north-west.
(d) Very cold to cold.
(e) (i) *Mulhausen*: Earthquake reported at 2200 h.
(ii) *St Diez*: Earthquake reported at 2130 h.

30th
(a) A similar situation to that of the 28th with a deep depression off the Norwegian coast and a frontal trough moving south-east over England and Wales.
(b) Light and variable becoming moderate NW.
(c) Occasional drizzle and fog patches at first with continuous moderate to heavy rain in the evening.
(d) Very cold.

551.508.71

THE USE OF THE LITHIUM CHLORIDE HYGROMETER (DEW-CELL) TO MEASURE DEW-POINT

By C. K. FOLLAND

Summary. Trials of a remote-indicating automatic hygrometer which directly measures dew-point are described. The hygrometer can operate without attention for long periods and is particularly suitable as a replacement for wet bulbs in freezing conditions when manual attention to the wet-bulb wick is impossible.

Introduction. A humidity-indicating instrument is required which can operate without attention at automatic weather stations or remote sites where manual attention to wet bulbs in freezing conditions is impossible. A similar instrument is required at synoptic stations where the instrument enclosure is far from the observing office, and remote-indicating instruments which can operate continuously are therefore required. A preliminary investigation of the lithium chloride (dew-cell) hygrometer by MacDowall[1] in 1956 gave promising results, and further trials were carried out by Sparks[2] in the late 1960s. The present paper describes the results of an intensive investigation of dew-cell performance in which use was made of a modified commercial sensor (Foxboro Type 2701 G24).

Principle of operation. Figure 1 shows the construction of the dew-cell. A 5 per cent solution of lithium chloride is applied to the woven glass-fibre tape which is wound on to a hollow lacquered brass tube. The solution is hygroscopic and absorbs water vapour from the atmosphere. It is also an electrical conductor. The solution is heated resistively by 24-carat gold bifilar windings to which a 25-volt a.c. supply is applied. The temperature of the solution rises at first but the heating effect is reduced when the solution starts to evaporate, since the crystals are poor conductors. An equilibrium is reached when the heat gained by resistive heating equals the heat lost to the environment. The equilibrium temperature depends on the ambient water-vapour pressure, increasing with vapour pressure, and is measured with a close-fitting platinum-resistance thermometer inserted in the hollow brass tube with its bulb half-way along the length of the tube. Plate I shows a typical dew-cell installation. The element is mounted at a height of 1·25 m and is protected from wind, rain and solar radiation by a double-walled, white-painted plastic shield with holes in the base and sides to allow circulation of air. As the dew-cell operates at a high temperature (e.g. about 48°C for a dew-point of 10°C) exchange of air is aided by convection. In series with the heating element is placed a 30-watt lamp whose increasing resistance with increasing current limits the maximum current to the dew-cell.

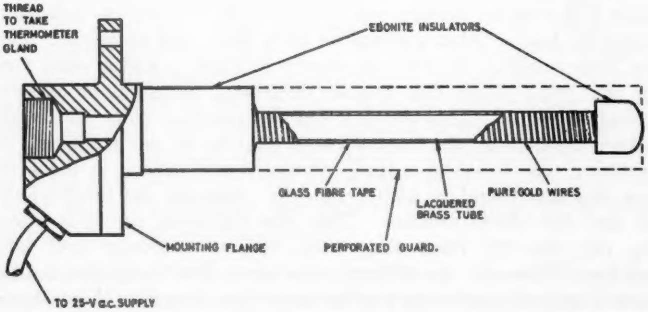

FIGURE 1—DEW-CELL CONSTRUCTION

Operating temperature of the dew-cell. The relationship between the temperature of the dew-cell and the dew-point has been investigated in the laboratory with a device which produces air of known dew-point with an estimated accuracy of about $\pm 0{\cdot}1$ degC.[3] Published data on the saturated vapour pressure of lithium chloride solution are not very reliable, but the equilibrium temperature also depends on the way in which heat is lost to the environment, and thus on the details of the construction of the dew-cell and its housing. It is found that different elements of the same type show a standard deviation of about 0·2 degC in their equilibrium temperature for the same dew-point. Thus a common calibration curve can be used in association with small residual corrections. In practice the temperature-measuring circuitry is arranged so that dew-point, rather than dew-cell temperature, is indicated directly.

Performance of the dew-cell in the field. The dew-cell has been compared with recording aspirated psychrometers[4] at Kew, Eskdalemuir and Lerwick Observatories and with naturally ventilated wet-bulb and dry-bulb thermometers at two synoptic stations, Little Rissington (Gloucestershire) and Brize Norton (Oxfordshire). At the observatories, chart recorders were used which gave observations at intervals of one minute or less, so that details of short-term fluctuations of dew-point could be investigated. It was found that when the period of fluctuation was a few minutes, the fluctuations recorded by the dew-cell tended to be exaggerated compared with those recorded by the aspirated psychrometers. This effect is due to the nature of the adjustment process of the dew-cell rather than to its speed of response, and can be markedly reduced by averaging the dew-point over a longer interval. In a typical period at Lerwick the standard deviation of departures of hourly mean dew-points measured by a dew-cell from those measured by an aspirated psychrometer was 0·22 degC, only half that of the hourly spot values (0·41 degC). Inspection of the records indicates that the more convenient period of a quarter of an hour would give almost as small a standard deviation.

Effect of ambient weather conditions. Laboratory investigation indicates that variations of wind speed should have only a small effect on the indicated dew-point, most of the effect occurring at wind speeds below 3 knots ($\approx 1{\cdot}5$ m/s) at dew-cell level. An increase in wind tends to cool the element slightly. At certain stations it appeared that as the wind speed increased, the dew-points indicated by the dew-cell decreased relative to those indicated by the psychrometers, but at other stations no such effect was apparent. The shield has since been modified to the form shown in Plate I, and a wind-tunnel test confirms that wind effects can now be neglected. It might be expected that solar radiation would affect the dew-cell temperature since the equilibrium temperature depends on the rate of loss of heat to the environment. No consistent relation was found in a trial conducted at Lerwick in the summer of 1970, nor was any found in winter 1970/71, between the functioning of the dew-cell and the cloud amount. Thus the radiation shield is effective in shielding the dew-cell from short-wave radiation receipt and long-wave radiation loss. However, the difference between the dew-points indicated by the dew-cell and the aspirated psychrometer was found to depend markedly on the relative humidity. Typically, the difference between indicated dew-points (dew-cell minus psychrometer) increased by 0·8 degC as the relative

humidity fell from 100 per cent to 40 per cent, the dew-point remaining effectively constant. The effect has been confirmed in the laboratory. It is believed to result from the way in which the dew-cell loses heat from the thermal mass adjacent to the flange (see Figure 1) which is exposed to the air. The higher the relative humidity, the higher the dew-cell temperature compared with the air temperature, and so the cell loses heat more readily at high relative humidities than at low relative humidities. The calibration curve has been constructed for a relative humidity of 65 per cent, and corrections are therefore required for other relative humidities.

Since the dew-cell operates at an elevated temperature, it might be expected that, in a fog, droplets would be evaporated round the dew-cell so that the latter would read too high a dew-point. The relationship is more complex, however. In conditions of hill-fog and sea-fog (Lerwick), there is a marked increase of indicated dew-point as visibility decreases. In dense fog the dew-point is typically 0·3 degC higher than that indicated at a relative humidity of 100 per cent in the absence of fog. However, in radiation fog, in a relatively polluted atmosphere (Kew), no increase in indicated dew-point was found. This is thought to be a result of the very low liquid-water content of such radiation fogs, owing to the small droplet size which is nevertheless effective in reducing visibility.

Tests of the dew-cell in freezing conditions highlighted the difficulties of operating psychrometers in these conditions. A long 'tail' of large positive dew-point excesses of the psychrometer over the dew-cell was often noted, and was not balanced by corresponding negative differences. This results from an insufficient covering of ice on the ice bulb. Readings of dew-point indicated by the dew-cell thus tend to be lower than those indicated by the psychrometer when the temperature is below freezing-point, and are more reliable.

Overall comparison of dew-cells with psychrometers. Nine different dew-cells were tested against eight different psychrometers. A total of about 45 000 sets of observations was collected. The standard deviation of spot values taken hourly (five sets of comparisons) was about 0·4 degC while that of daily means (eight sets of comparisons) was typically about 0·3 degC. The mean differences between dew-cells and psychrometers at individual stations varied between +0·56 degC and −0·42 degC in a way not obviously related to the type of psychrometer (i.e. aspirated or naturally ventilated, or fitted with mercury-in-glass or electrical-resistance thermometers). The overall mean difference of dew-point (dew-cell minus aspirated-psychrometer) was −0·01 degC (four sets of comparisons); the difference for (dew-cell minus naturally ventilated mercury psychrometer) was −0·05 degC (seven sets of comparisons). The observed spread of systematic mean differences between the dew-cell and psychrometer readings is as much a function of the psychrometer performance as of that of the dew-cells; careful laboratory investigation suggests that real differences between individual dew-cells would contribute only half the spread. Great care has to be taken over the arrangements for measuring the temperature in both types of instrument, and some of the variation can be attribted to instabilities in the resistance thermometry.

Conclusions. The lithium chloride hygrometer is a suitable replacement for the wet-bulb thermometers in freezing conditions and is a useful instrument under all conditions. Its main limitations are that it needs to be periodically 're-doped' with lithium chloride solution (about once every two months) owing

to the effects of atmospheric pollution, and has to be immediately re-doped after a power failure lasting more than a few tens of minutes, failing which erroneous readings can result. It is also less accurate than a psychrometer in high humidities, particularly in fog. It uses too much power for battery-operated automatic weather stations, but the present generation of Meteorological Office Weather Observing Systems (MOWOS[5]) is mains-powered, and a mains supply is always available at synoptic stations. The dew-cell has now been officially accepted for operational use where a remote-reading device for measuring humidity is justified. MOWOS is already being equipped with dew-cells in addition to naturally ventilated psychrometers.

Acknowledgements. The author wishes to thank the staffs of the stations which took part in the field trials and in particular Mr J. B. Tyldesley, who wrote the first report on the trials. Thanks are also due to Messrs G. Cromarty and F. Lumb for their careful work in the laboratory.

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551.594.22:629.7

ELECTRICAL PHENOMENA OBSERVED AT NIGHT IN THE TROPICS FROM A HERCULES AIRCRAFT

By Squadron Leader N. LAMB
(Officer Commanding Meteorological Research Flight, RAE Farnborough)

Summary. While a Hercules W Mk2 was flying at night at flight level 200 off Dakar a series of vivid electrical discharges was observed on part of the aircraft's external instrumentation; these discharges were apparently associated with lightning.

On 12 August 1974 I was Captain of the Meteorological Research Flight Hercules W Mk2 taking part in a multi-aircraft mission in Project GATE. We left Dakar at 0520 GMT to transit at flight level 200* to a ship position at 09°N 22°W. The first 180 miles were uneventful and, although we were in cloud all the way, conditions were smooth with little or no icing. It was very dark. At position 12°N 20°W, the weather radar had shown cloud, but with no iso-echo returns, light turbulence and icing were experienced, and electrical disturbance was evident. At regular intervals of somewhere between 30 seconds and one minute, and lasting approximately three seconds, there appeared a colourful cascade of electrical discharges between the trailing edges of each of the four wind vanes and about 50 cm aft, where the nose probe begins to thicken. (The axes of rotation of the wind vanes lie in a plane perpendicular to the axis of the nose probe, and are symmetrically distributed above,

* i.e. at a height shown on the altimeter as 20 000 feet.

below, and to either side of the probe.) This was observed about three times, to be replaced, at approximately the same interval, by what appeared to be lightning in the cloud below and to the right. The co-pilot's impression was that it was below and to the left. A close watch on the nose probe showed that the tip began to glow yellow until, over a period of about three seconds, it reached a certain white intensity; the glow then disappeared simultaneously with the occurrence of what appeared to be distant lightning flashes. Static interference was heard in the headphones during each three-second period.

The phenomenon could not be observed on the forward-looking television cameras as there was too much interference on the screens at the time. A camera was brought forward in the hope of photographing the 'cascade' but unfortunately that particular phenomenon did not recur.

That the nose probe is liable to attract lightning in this manner had been shown by a previous incident which took place in March 1974 while the same aircraft was flying over the United Kingdom at 2000 feet and just below what appeared to be a layer of stratocumulus. The cloud just above where the strike occurred was darker than the general cloud in the area but it had not shown on the weather radar as a particularly active cloud. Damage to the aircraft was slight; one wind-vane was pitted, there was very shallow pitting on the stainless-steel pitot head and shaft, and the nose boom was peppered with small holes as far aft as the television-camera windows. The Lightning Research Department of the Royal Aircraft Establishment advised that with the Hercules W Mk2, the nose boom would be the place most likely to attract lightning.

AWARDS

L. G. Groves Memorial Prizes and Awards

In 1946 Major and Mrs K. G. Groves instituted three prizes to be awarded annually in memory of their son, Sergeant (Meteorological Air Observer) Louis Grimble Groves, R.A.F.V.R., of No. 517 Squadron, Coastal Command, who lost his life while flying on a meteorological sortie on 10 September 1945.

The L. G. Groves Memorial Prize for Aircraft Safety is awarded for the most important contribution made during the year towards the safety of aircraft and flying personnel. All members of the Royal Air Force are eligible for this prize, which is awarded on the recommendation of a board under the chairmanship of the Director of Flight Safety, Royal Air Force.

The L. G. Groves Memorial Prize for Meteorology is awarded for the most important contribution made during the year, either to the science of meteorology, or to the application of meteorology to aviation. All members of the Meteorological Office and the Royal Air Force are eligible. The prize is awarded on the recommendation of a board under the chairmanship of the Director of Research, Meteorological Office.

The L. G. Groves Memorial Award for Meteorological Observers is made to an officer employed on flying duties, or to a member of aircrew, service or civilian, who has been employed on meteorological observer duties, or other flying duties relating to meteorology, or to British or Commonwealth personnel

engaged in operational meteorology on ocean weather ships, for meritorious work or devotion to duty during the previous year. The award is made on the recommendation of a board under the chairmanship of the Director of Research, Meteorological Office.

In 1960 Major and Mrs Groves made a further generous donation to increase the values of the existing prizes and award and to set up a fourth to be known as the 'Second Memorial Award'. It is given, at the discretion of the Ministry of Defence, for meritorious work in any of the fields covered by the existing prizes and award, or in operational meteorology.

The 28th annual presentation of the prizes and awards took place on Thursday 7 November 1974 in the Main Conference Room, Ministry of Defence, Whitehall, and was presided over by the Vice Chief of Air Staff, Air Marshal Sir Ruthven Wade, K.C.B., D.F.C. Also present were Air Commodore D. F. M. Browne, C.B.E., A.F.C., Director of Flight Safety, Royal Air Force, and Dr B. J. Mason, C.B., F.R.S., Director-General of the Meteorological Office. It was for Major and Mrs Groves, who as in previous years presented the prizes, a doubly felicitous occasion since it was also their Diamond Wedding anniversary. (See Plates II–V.)

The Prize for Air Safety was awarded to Sergeant M. Dubey, Royal Air Force, Tern Hill, who devised a modification to the Mk 17/17a Life Preserver following an investigation into faulty operation. In proposing the modification Sergeant Dubey has made a worthwhile contribution towards the survival of aircrew obliged to abandon their aircraft over the sea.

The Prize for Meteorology went to Dr C. J. Readings of the Meteorological Research Unit, Royal Air Force, Cardington, with the following citation:

> 'As leader of a small scientific team based at Cardington, Dr C. J. Readings has been responsible for the development of techniques for the measurement of atmospheric structure from the cable of a tethered balloon, and for exploiting these techniques for the study of turbulence in the lower atmosphere. Comparisons with similar measurements by different techniques developed in the United States of America have shown for the first time that reliable measurements are being obtained of certain important but elusive quantities—the flux of heat, momentum and moisture through the lower atmosphere. Dr Readings has also made important contributions to the interpretation and analysis of these measurements which promise a greatly improved understanding of turbulence in the lower atmosphere.'

The Award for Meteorological Observers was won by Flight Lieutenant F. Robertson of the Meteorological Research Flight, Royal Aircraft Establishment, Farnborough. The citation states that:

> 'During his service with the Meteorological Research Flight, Flight Lieutenant Robertson's diligence and skill as a navigator has contributed directly to the success of the meteorological research particularly during the planning and execution of flights through wave-motion in the lee of mountains during project WAMFLEX. Flight Lieutenant Robertson's enthusiasm in studying the potentialities of the stable platform on the new Hercules aircraft has also enabled the capability of the aircraft for wind measurements to be exploited to the full.'

The Second Memorial Award was made to Flight Lieutenant D. R. Gasson, Royal Air Force, Lossiemouth, who had shown considerable resourcefulness in adapting the D Mk 1 parachute harness carried by the crews of Shackleton

aircraft, at present unsuitable for continuous wear, and therefore impracticable in an emergency with insufficient time to don the harness. Flight Lieutenant Gasson's proposals will significantly enhance the chances of survival for Shackleton crews obliged to abandon their aircraft in an airborne emergency.

Proxime accessit. Flying Officer Trudi Cant, Royal Air Force, Odiham received an air safety citation. She was, to the obvious delight of Major Groves, the first woman to have reached the 'top five'.

REVIEW

Dynamic meteorology, edited by P. Morel. (Lectures delivered at the Summer School of Space Physics of the Centre National d'Études Spatiales held at Lannion, France, 7 August–12 September 1970.) 245 mm × 165 mm, pp. 622, *illus.*, D. Reidel Publishing Co., P.O. Box 17, Dordrecht, Holland, 1973. Price: 115 Dfl.

This book is based on lectures delivered at a Summer School sponsored by the Centre National d'Études Spatiales held at Lannion, France, in 1970. The list of contributors—Phillips, Charney, Lilly, Monin, Morel and Queney—contains some of the most influential figures in dynamical meteorology in recent years.

The first section of about 90 pages is a succint account of the principles of large-scale numerical weather prediction by Professor Phillips. The material is well known, apart possibly from the precise method of illustrating the initialization problem, which does not seem to have appeared elsewhere. The choice of topics and their presentation is impeccable.

The second series of lectures (150 pages) on 'Planetary fluid dynamics' by Professor Charney is more discursive. The bulk of it is concerned with solving particular problems, which have been identified in the atmosphere by analytical methods, for which questions of scaling, dependence on non-dimensional numbers and appropriate linearizations are fundamental concepts. The range of problems treated is very wide and the fact that Professor Charney has made definitive contributions to almost all of them is a measure of his immense influence on meteorological thought.

The remaining contributions are on rather more narrowly defined aspects of meteorology, allowing the authors a more leisurely presentation. Professor Lilly uses the mathematical theory of turbulence to expound the problems of subsynoptic-scale motions and their impact upon predictability, clear-air turbulence and convective parameterization. Professor Monin's account of the boundary layer follows familiar lines dependent on similarity theory as pioneered by Russian scientists and goes on to consider its application to planets other than the earth. The lectures by Professor Morel on data analysis and initialization are very clear, and based essentially on Gandin's theory of optimum interpolation. Finally, Professor Queney presents a fairly detailed mathematical treatment of the theory of mountain waves.

The book has been reproduced photographically from the typewritten text with the mathematics inserted by hand. This is obviously not ideal and occasions a larger number of editorial blemishes than normal; figures, for instance,

are not always sequential and sometimes have no numbers. However, it is usually clear and adequate for the essential purpose. We have to be thankful that the publishers have found a format that has enabled them to make such a distinguished set of lectures available to a wider public.

A. GILCHRIST

LETTER TO THE EDITOR

Association of British Climatologists—New Directory

I should like to draw the attention of readers of the *Meteorological Magazine* to the fact that a second Directory of British Climatologists is being prepared under the aegis of the Association of British Climatologists. It is intended to make this as comprehensive as possible, containing categorized information on climatologists in Britain, their affiliations, research interests and recent publications, and we hope that every scientist working in the field of climatology will be willing to contribute.

Anyone interested in being included in this Directory should contact me at the address below as soon as possible.

(PROFESSOR) S. GREGORY

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CORRECTIONS

Meteorological Magazine, September 1974.

Page 246, Figure 4: caption should read 'Contours of u_{10}/V_g in terms of R and V_g'.

Page 250, Table I: centre heading should read u_z/u_{10}.

Page 252, line 11: equation should read

$$\Delta_h V_g = \frac{h}{1000}.\Delta V_g \equiv 3{\cdot}3\ \Delta_h T,$$

Page 253, Figure 10: centre right-hand horizontal axis with values 2–14 should be labelled u_{10} m/s.

Page 254, line 8: $u_1/u_{10} \approx 0{\cdot}75$ should read $u_z/u_{10} \approx 0{\cdot}75$.

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NOTICES

It is requested that all books for review and communications for the Editor be addressed to the Director-General Meteorological Office, London Road, Bracknell, Berkshire, RG12 2SZ, and marked 'For Meteorological Magazine'.

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